

What is claimed is:

1. A receive front-end module for use in a multi-band, multi-mode communication device, the communication device having a plurality of electrically separated antennas,  
5 said receive front-end module comprising:
  - at least two feed points, separately connected to at least two of said plurality of antennas for receiving communication signals in the communication device;
  - a plurality of signal paths, operatively connected to the feed points for simultaneously receiving communication signals in a plurality of frequency bands,
  - 10 wherein each signal path has a filter for filtering the communication signals in the corresponding frequency band; and
  - at least one isolation component, disposed in the signal paths, for providing cross-band isolation between at least two of the signal paths.
- 15 2. The receive front-end module of claim 1, wherein said isolation component comprising at least one signal amplifier.
3. The receive front-end module of claim 1, wherein said at least two antennas comprise a first antenna and a second antenna, and said at least two feed points comprises  
20 a first feed point operatively connected to the first antenna, and a second feed point operatively connected to the second antenna, and wherein said plurality of signal paths comprises:
  - a first signal path having a first filter for filtering the communication signals in the first frequency band, the first signal path operatively connected to the first feed point;
  - 25 a second signal path having a second filter for filtering the communication signals in the second frequency band, the second signal path operatively connected to the second feed point;
  - a third signal path having a third filter for filtering the communication signals in the third frequency band, the third signal path operatively connected to the second feed point, wherein the third frequency band is different from the second frequency band; and
  - 30 at least one matching circuit for matching the second and third filters.

4. The receive front-end module of claim 3, further comprising:  
a first balun disposed in the first signal path between the first filter and the first  
feed point;  
a second balun disposed in the second signal path between the second filter and the  
5 second feed point; and  
a third balun disposed in the third signal path between the third filter and the  
second feed point.

5. The receive front-end module of claim 4, wherein said isolation component  
10 comprises:  
a first signal amplifier disposed in the first signal path, operatively connected to the  
first filter;  
a second signal amplifier disposed in the second signal path, operatively connected  
to the second filter; and  
15 a third signal amplifier disposed in the third signal path, operatively connected to  
the third filter.

6. The receive front-end module of claim 3, wherein  
the first frequency band substantially covers a frequency range of 1805 - 1880  
20 MHz,  
the second frequency band substantially covers a frequency range of 1930 - 1930  
MHz, and  
the third frequency band substantially covers a frequency range between 2110  
MHz and 2170 MHz.

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7. The receive front-end module of claim 6, wherein  
the communication signal received in the first signal path is transmitted in a GSM  
mode;  
the communication signal received in the second signal path is transmitted either in  
30 a GSM mode or a W-CDMA mode; and  
the communication signal received in the third signal path is transmitted in a  
CDMA mode.

8. The receive front-end module of claim 3, wherein the first frequency band is substantially the same as the second frequency band.

5 9. The receive front-end module of claim 8, wherein  
the third frequency band substantially covers a frequency range between 1805  
MHz and 1880 MHz ; and  
the first and second frequency bands substantially cover a frequency range between  
2110 MHz and 2170 MHz.

10 10. The receive front-end module of claim 9, wherein  
the communication signal received in the third signal path is transmitted in a GSM  
mode; and  
the communication signals received in the first and the second signal paths are  
15 transmitted in a W-CDMA mode.

11. The receive front-end module of claim 8, further comprising:  
a first balun disposed in the first signal path between the first filter and the first  
feed point;  
20 a second balun disposed in the second signal path between the second filter and the  
second feed point; and  
a third balun disposed in the third signal path between the third filter and the  
second feed point.

25 12. The receive front-end module of claim 8, wherein said isolation component  
comprises:  
a first signal amplifier disposed in the first signal path, operatively connected to the  
first filter;  
a second signal amplifier disposed in the second signal path, operatively connected  
30 to the second filter; and  
a third signal amplifier disposed in the third signal path, operatively connected to  
the third filter.

13. The receive front-end module of claim 1, wherein said at least two antennas comprise a first antenna and a second antenna, and said at least two feed points comprise a first feed point operatively connected to the first antenna, and a second feed point  
5 operatively connected to the second antenna, and wherein said plurality of signal paths comprises:

a first signal path having a first filter for filtering the communication signals in the first frequency band, the first signal path operatively connected to the first feed point, and

10 a second signal path having a second filter for filtering the communication signals in the second frequency band, the second signal path operatively connected to the second feed point, and wherein said plurality of antennas further comprising a third antenna electrically separated from the first and second antenna, said module further comprising:

a third feed point, operatively connected to the third antenna for receiving communication signals in the communication device;

15 a third signal path, operatively connected to the third feed points for receiving communication signals in a third frequency bands; and

further means, disposed in the third signal path, for providing cross-band isolation between the third signal path and at least one of said at least two signal paths.

20 14. The receive front-end module of claim 13, wherein the communication signal received in the first and second signal paths is transmitted in a frequency band substantially between 2110 MHz and 2170 MHz.

25 15. The receive front-end module of claim 14, wherein the communication signal received in the third signal path is transmitted in a frequency band substantially between 1930 MHz and 1990 MHz.

16. The receive front-end module of claim 13, further comprising:

30 a first balun disposed in the first signal path between the first filter and the first feed point;

a second balun disposed in the second signal path between the second filter and the second feed point; and

a third balun disposed in the third signal path between the third filter and the second feed point.

17. The receive front-end module of claim 16, wherein said isolation component  
5 comprises:

a first signal amplifier disposed in the first signal path, operatively connected to the first filter; and

a second signal amplifier disposed in the second signal path, operatively connected to the second filter, and wherein said further isolation means comprises

10 a third signal amplifier disposed in the third signal path, operatively connected to the third filter.

18. The receive front-end module of claim 15, further comprising

a fourth signal path operatively connected to a different one of said plurality of  
15 antennas for receiving communication signals in a frequency band substantially between 1930 MHz and 1990 MHz.

19. The receive front-end module of claim 18, wherein the received communication signals in first and second signal paths are transmitted in one of the following modes: W-  
20 CDMA (EU) and W-CDMA (US2).

20. The receive front-end module of claim 19, wherein the received communication signals in the third and fourth signal paths are transmitted in one of the following modes: W-CDMA (US1) and 1900GSM.  
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21. The receive front-end module of claim 19, wherein the received communication signals in the third signal path are transmitted in W-CDMA (US1) mode, and the received communication signals in the fourth signal path are transmitted in one of the following modes: W-CDMA (US1) and 1900GSM.  
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22. The receive front-end module of claim 16, wherein the baluns are integrated in a sub-module.

23. The receive front-end module of claim 17, wherein the signal amplifiers are integrated in a sub-module.

5 24. The receive front-end module of claim 18, comprising:  
a first sub-module for disposing the first, second and third feed points and the first, second and third signal paths; and  
a second sub-module for disposing the fourth signal path.

10 25. The receive front-end module of claim 17, further comprising:  
a further antenna having a further feed point;  
a fourth signal path, operatively connected to the further feed point, for receiving a communication signal in a fourth frequency band;  
a fifth signal path, operatively connected to the further feed point, for receiving a  
15 communication signal in a fifth frequency band different from the fourth frequency band, wherein each of the fourth and fifth signal paths has  
an input end and an output end, the input end operatively connected to the further feed point,  
a balun disposed at the input end,  
20 a signal amplifier disposed at the output end, and  
a filter disposed between the signal amplifier and the balun; and  
means, operatively connected to the further feed point, for matching the filters in the fourth and fifth signal paths.

25 26. The receive front-end module of claim 25, wherein  
the communication signals received in the first and second signal paths are transmitted in a frequency band substantially between 2110 MHz and 2170 MHz in a W-CDMA mode, and  
the communication signals received in the third and fourth signal paths are  
30 transmitted in a frequency band substantially between 1930 MHz and 1990 MHz in either a W-CDMA mode or a GSM mode.

27. The receive front-end module of claim 26, wherein the communication signals received in the fifth signal path are transmitted in the fifth frequency band substantially between 1805 MHz and 1880 MHz.

- 5 28. The receive front-end of claim 25, comprising:  
a first sub-module for disposing the first, second and third signal paths and the first, second and third feed points, and  
a second sub-module for disposing the fourth and fifth signal paths and the further feed point.

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29. The receive front-end module of claim 25, further comprising  
a sixth signal path, operatively connected to the further feed point, for receiving a communication signal in a sixth frequency band different from the fourth and the fifth frequency band, the sixth signal path having

- 15 an input end and an output end, the input end operatively connected to the further feed point,

a balun disposed at the input end,  
a signal amplifier disposed at the output end, and  
a filter disposed between the signal amplifier and the balun for filtering the

- 20 communication signal in the sixth frequency band, wherein  
the matching circuit is also used for matching the filter in the sixth signal path.

30. The receive front-end module of claim 29, wherein  
the communication signals received in the first, second and sixth signal paths are  
25 transmitted in a frequency band substantially between 2110 MHz and 2170 MHz in a W-CDMA mode,

the communication signals received in the third and fourth signal paths are transmitted in a frequency band substantially between 1930 MHz and 1990 MHz in either a W-CDMA mode or a GSM mode, and

- 30 the communication signals received in the fifth signal path are transmitted in the fifth frequency band substantially between 1805 MHz and 1880 MHz.

31. The receive front-end module of claim 13, wherein said at least two antennas comprise a first antenna and a second antenna, and said at least two feed points comprises:  
a first feed point, operatively connecting a first signal path to the first antenna, for receiving communication signals in a first frequency band, and

5 a second feed point, operatively connecting a second signal path to the second antenna, for receiving communication signals in the second frequency band, and said plurality of antenna further comprising a fourth antenna, a fifth antenna, and a sixth antenna, and the receive front-end module further comprises:

10 a fourth feed point, operatively connecting a fourth signal path to the fourth antenna, for receiving communication signals in the fourth frequency band;

a fifth feed point, operatively connecting a fifth signal path to the fifth antenna, for receiving communication signals in the fifth frequency band; and

15 a sixth feed point, operatively connecting a sixth signal path to the sixth antenna, for receiving communication signals in the sixth frequency band, and wherein the receive front-end module comprises a first sub-module for disposing the first, second and third signal paths, and a second sub-module for disposing the fourth, fifth and sixth signal paths, and the

communication signals in at least two of the six signal paths are transmitted in the same frequency band and transmission mode.

20 32. The receive front-end of claim 31, wherein said at least two of the six signal paths comprise:

the first and fourth signal paths in which the received communication signals are transmitted substantially in a frequency range between 2110 MHz and 2170 MHz;

25 the second and third signal paths in which the received communication signals are transmitted substantially in a frequency range between 1930 MHz and 1990 MHz; and

the fifth and sixth signal paths in which the received communication signals are transmitted substantially in a frequency range between 1805 and 1880 MHz.

30 33. A method of enhancing reception of communication signals in a multi-band, multi-mode communication device, the communication device having a plurality of electrically



separated antennas, and a plurality of signal paths for receiving communication signals in a plurality of frequency bands, said method comprising the steps of:

providing at least a first feed point and a second feed point separately connected to at least two of said plurality of antennas;

5           operatively connecting at least one of said plurality of signal paths to the first feed point, and at least a different one of said plurality of signal paths to the second feed point, each of the signal paths connected to the first and second feed points has a filter for filtering the communication signals in the corresponding frequency band; and

10           providing means, in at least some of the signal paths, for providing cross-band isolation between at least two of said plurality of signal paths, wherein

the communication signals received in at least one of the signal path connected to the first feed point and the communication signals received in at least one the signal path connected to the second feed point are transmitted in the same frequency band and transmission mode.

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34.    A multi-band, multi-mode communication device, comprising:

a plurality of electrically separated RF antennas, including a first antenna and a second antenna, and

a front-end module comprising:

20           at least a first feed point and a second feed point separately connected to the first and second antennas, and

a plurality of signal paths operatively connected to the first and second feed points for receiving communication signals in a plurality of frequency bands, each signal path having a filter for filtering the communication signals in the

25           corresponding frequency band, wherein

the communication signals received in at least one of the signal path connected to the first feed point and the communication signals received in at least one the signal path connected to the second feed point are transmitted in the same frequency band and transmission mode.

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35.    The portable communication device of claim 34, comprising a mobile terminal.

36. The portable communication device of claim 34, comprising a communicator device.